Workshop on:

Rainfall–Runoff Simulation Supporting with GIS and Satellite Data

Speaker:
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Main components of HEC-HMS

Objectives

- Become familiar with the program and learn basic concepts of program organization, data components, and simulation runs.
- Understand the different hydrologic elements and the methods available for each one.
- See the different types of results visualization and statistical summaries.
- Preview advanced capabilities.

Program Scope

Designed to simulate watershed hydrology.

- Surface water modeling.
- From meteorology to watershed outlet.

Tool kit of options.

- Generalized modeling.
- Mathematical model choices.
- Analysis tools.

Graphical user interface

- Map of the watershed.
- Point-and-edit for entering and updating data.
- Graph and table displays of simulation results.

Program Limitations

Deterministic models.

Uncoupled models.

- Evapotranspiration-infiltration.
- Infiltration-baseflow.

No aquifer interactions.

Constant parameter values.

Dendritic stream systems.

- Flow splits possible but limited capability.

No downstream flow influence or reversal.

- Backwater possible but only if contained within a reach.

Project

Container for main components.

- Basin model.
- Meteorologic model.
- Control specifications.

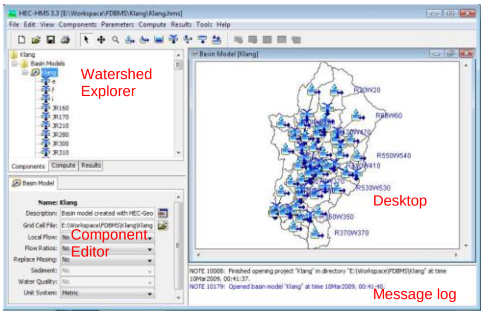
Also holds additional components.

- Time-series gages.
- Paired data functions.
- Grid data sets.

Provides analysis tools.

- Parameter estimation using optimization theory.
- Depth-area analysis for frequency storm.

HEC-HMS main view



Data Management

Configuration data and parameters.

- Files within the project directory.
- Automatically created, saved, loaded, etc.

Data Storage System HEC-DSS.

- Time-series and paired data can be manually entered or retrieved from external files.
- Grid data can only be retrieved from external files.
- All time-series results computed during a simulation.

Automatic data handling.

- Units conversion.
- Interpolation or accumulation.

Main Components

Basin model gives the physical description of the watershed.

- Subbasin: watershed catchments where rain falls.
- Reach: rivers and streams.
- Reservoir: dams and lakes.
- Junction: confluence.
- Diversion: bifurcations and withdrawls.
- Source: springs and other model sinks.
- Sink: outlets and terminal lakes.

Meteorologic model describes atmospheric conditions over the watershed land surface.

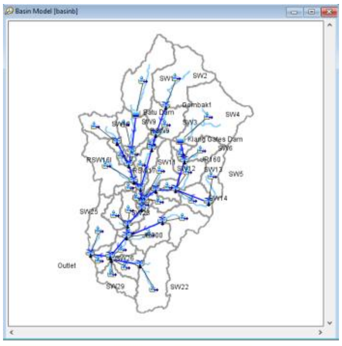
- Precipitation.
- Potential evapotranspiration.
- Snowmelt.

Control specifications: Time control during a simulation run.

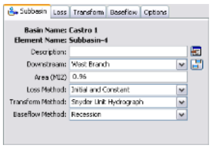
Program Application

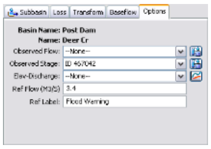
- Create a new project.
- Enter time-series, paired data, and grid data.
- Create a basin model.
- Create a meteorologic model.
- Create control specifications.
- Create and compute a simulation run.
- View results.
- Create other alternatives, compute, and compare results.
- Save the project and exit.

Basin Map



Hydrologic Elements

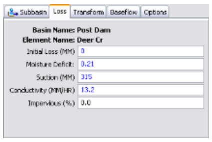




Subbasin Infiltration

Loss rate methods:

- Deficit constant.
- Exponential.
- Green Ampt.
- Gridded deficit constant.
- Gridded SCS.
- Gridded SMA.
- Initial constant.
- SCS curve number.
- Smith Parlange.
- Soil moisture accounting.



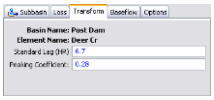
Subbasin Surface Runoff

Unit hydrograph methods:

- Clark.
- SCS.
- S-graph.
- Snyder.
- User-specified.

Other methods:

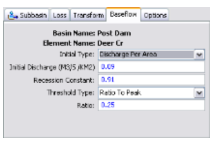
- Kinematic wave.
- ModClark distributed.



Subbasin Baseflow

Baseflow methods:

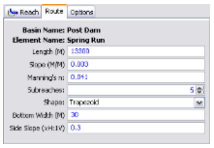
- Bounded recession.
- Linear reservoir.
- Monthly constant.
- Nonlinear Boussinesq.
- Recession.



Reach

Routing methods:

- Kinematic wave
- Lag
- Modified Puls
- Muskingum
- Muskingum-Cunge
- Straddle stagger



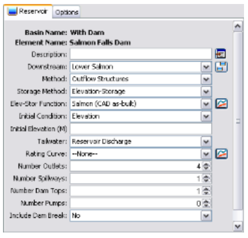
Loss/gain methods:

- Constant.
- Percolation.

Reservoir

Routing methods:

- Storage curve.
- Outlet structures.
- Specified release.



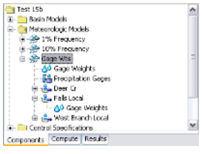
Possible structures:

- Gated spillway (0 to 10).
- Overflow (0 to 10).
- Outlet (0 to 10).
- Pump (0 to 10).
- Dam break (0 or 1).

Precipitation

Historical methods:

- Gage weights.
- Inverse distance.
- User-specified.
- Gridded.



Hypothetical methods:

- Frequency storm.
- SCS storm.
- Standard project storm.

Evapotranspiration

Available methods:

- Gridded Priestley-Taylor.
- Monthly average.
- Priestley-Taylor.

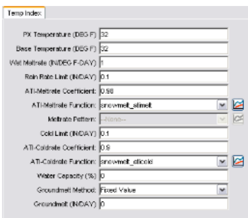
Evapotranspiration

Month	Rate (IN/MONTH)	Pan Coefficient
January	2.22	0.7
February	2.78	0.7
March	4.53	0.7
April	5.29	0.7
May	7.08	0.7
June	6.97	0.7
July	6.81	0.7
August	6.32	0.7

Snowmelt

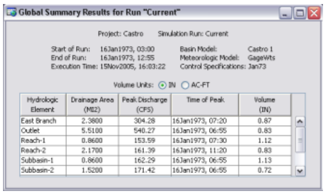
Temperature index method.

- Subbasin band approach.
- Gridded approach.



- Consists of one basin model, meteorologic model, and control specifications.
  - Precipitation or outflow ratio option.
  - Start states option.
  - Save states option.
- View results for the current simulation run using menu or toolbar
  - Global summary table.
- View results for one element in the current simulation run using the menu, toolbar, or basin map.
  - Graph, summary table, time-series table.
- View custom graphs and time-series tables for elements in different simulation runs using the *Watershed Explorer*.

Global Summary Table


Global Summary Results for Run "Current"

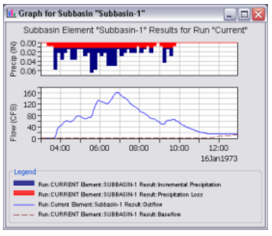
Project: Castro   Simulation Run: Current

Start of Run: 16Jan1973, 03:00   Basin Model: Castro 1
End of Run: 16Jan1973, 12:55   Meteorologic Model: GageWts
Execution Time: 15Nov2005, 16:03:22   Control Specifications: Jan73

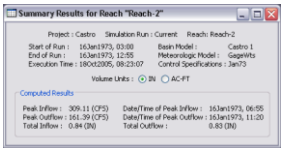
Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
East Branch	2.3800	304.28	16Jan1973, 07:20	0.87
Outlet	5.5100	540.27	16Jan1973, 06:55	0.83
Reach-1	0.8600	153.59	16Jan1973, 07:30	1.12
Reach-2	2.1700	161.39	16Jan1973, 11:20	0.83
Subbasin-1	0.8600	162.29	16Jan1973, 06:55	1.13
Subbasin-2	1.5200	171.42	16Jan1973, 06:55	0.72

Element Graph



Element Summary Table


Summary Results for Reach "Reach-2"

Project : Castro   Simulation Run : Current   Reach: Reach-2

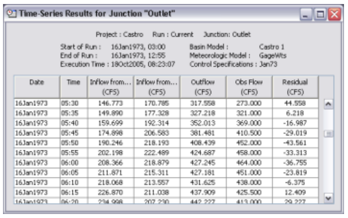
Start of Run : 16Jan1973, 03:00   Basin Model : Castro 1
End of Run : 16Jan1973, 12:55   Meteorologic Model : GageWts
Execution Time : 18Oct2005, 08:23:07   Control Specifications : Jan73

Volume Units : IN AC-FT

Computed Results

Peak Inflow : 309.11 (CFS)   Date/Time of Peak Inflow : 16Jan1973, 06:55
Peak Outflow : 161.39 (CFS)   Date/Time of Peak Outflow : 16Jan1973, 11:20
Total Inflow : 0.84 (IN)   Total Outflow : 0.83 (IN)

Element Time-Series Table



Time-Series Results for Junction "Outlet"

Project : Castro   Run : Current   Junction: Outlet

Start of Run : 16Jan1973, 03:00   Basin Model : Castro 1
End of Run : 16Jan1973, 12:55   Meteorologic Model : GageWts
Execution Time : 18Oct2005, 08:23:07   Control Specifications : Jan73

Date	Time	Inflow from... (CFS)	Inflow from... (CFS)	Outflow (CFS)	Obs Flow (CFS)	Residual (CFS)
16Jan1973	05:30	146.773	170.785	317.558	273.000	44.558
16Jan1973	05:35	149.890	177.328	327.218	321.000	6.218
16Jan1973	05:40	159.699	192.314	352.013	369.000	-16.987
16Jan1973	05:45	174.898	206.583	381.481	410.500	-29.019
16Jan1973	05:50	190.246	218.193	408.439	452.000	-43.561
16Jan1973	05:55	202.198	222.489	424.687	458.000	-33.313
16Jan1973	06:00	208.366	218.879	427.245	464.000	-36.755
16Jan1973	06:05	211.871	215.311	427.181	451.000	-23.819
16Jan1973	06:10	218.068	213.557	431.625	438.000	-6.375
16Jan1973	06:15	226.870	211.038	437.909	425.500	12.409
16Jan1973	06:20	234.998	207.230	442.227	413.000	29.227

Continuous Simulation

"Event" simulation is only concerned with hydrology during and immediately after a storm.

"Continuous" simulation includes events and the time between them, up to several decades at a time.

Loss rate methods:

- Deficit constant.
- Soil moisture accounting.

May be needed to satisfy some study goals:

- Reproduce frequency curve.
- Water balance estimates.
- Flow rates or volumes beyond instantaneous peaks.

Gridded Simulation

Precipitation, evapotranspiration, and snowmelt are defined on a grid cell basis.

Infiltration and excess precipitation is computed separately for each cell.

ModClark transform method is used to process excess precipitation into runoff at the subbasin outlet.

Better definition of subbasin response:

- Storm is small compared to the subbasin size.
- Storm is very heterogeneous.

Advanced Reservoir Features

- Interior flood protection projects.
  - Represents a pond on the "dry" side of a levee or floodwall where local drainage water accumulates.
  - Include culverts to pass water through the levee into the river when the river stage is low.
  - Include pumps to move water over the levee during floods.
- Dam break evaluations.
  - Simulate the dam release from piping or overtopping failures.

Parameter Estimation

- Automated tool for estimating parameters when observed flow is available.
- "Objective function" measures how well the computed and observed flow hydrographs match.
- "Search method" uses the objective function as input to an algorithm that determines how to adjust parameter values to find the optimum match.
- Can provide good estimates for some parameters:
  - Infiltration initial conditions and parameters.
  - Unit hydrograph parameters.
  - Baseflow initial conditions and parameters.
  - Some routing parameters.

Depth-Area Analysis

- Frequency storm is often used for estimating flows due to the 100-yr storm or other return intervals.
- Large watersheds often have many locations where flow estimates are required.
- It can be tedious to develop storms with the correct area for each of the locations.
- Analysis tool uses a simulation run and automatically adjusts the storm area for each selected location.

Exercise 3:

- Open you HEC-HMS and import your project generated by HEC-GeoHMS
- Set hydrograph transformation for SCS method
- Set HEC-HMS for kinematic waves routing method
- Set base flow for monthly constant
- Set infiltration for SCS method
- Set meteorological inputs
- Set control specifications
- Input required data for each part
- Run the model and report your result.

Thank you

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